VE-53-DH Short Period Seismometer
Operating manual

GeoSIG Ltd, Wiesenstrasse 39, 8952 Schlieren, Switzerland
Phone: + 41 44 810 2150, Fax: + 41 44 810 2350
info@geosig.com, www.geosig.com

DOCUMENT REVISION

Rev	Description	Prepared by	Checked by	Approved by	Date
0	First Issue	ALB	ANF	BES	2023-10-12
File name:	GS_VE-53-DH_Operation_Manual_V0.docx				
Doc. NR.:					
Project:	GS_33478				
Title:	VE-53-DH Short Period Seismometer			PUBLIC	

TABLE OF CONTENTS

Warnings and Safety

☞ *The sensor housing provides no protection against explosive atmosphere. It must not be directly operated in area where explosive gases are present.*

1. Introduction

The **VE-53 -DH** is a triaxial short-period seismometer designed for downhole installations. This type of sensor gives a very good stability in temperature and aging because of the very simple principle. It uses a damped mass spring transducer called "Geophone". By means of a feedback electronics stage and an integration stage, the sensor returns a velocity signal on its output. Its sensitivity (1000 V/m/s) makes it well suitable for monitoring seismometer applications, with a typical local or regional measurement range of M1 or M1.5 (<100km).

With the help of the TEST INPUT signal, the sensor's electronics can be easily tested. Typically, the sensor is equipped with the *iSensor* module**,** for fast deployment on the field, proper orientation and placement.

The VE-53-DH comes with a 502 mm tall, 89mm diameter cylindric stainless-steel case that guarantees watertightness up to 10 bars (100 meters depth). The sensor is mainly intended for shallow downhole installation (typically in a range within 10m depth), where levelling can be easily guaranteed by the borehole construction and where the attenuation in bandwidth of the ambient noise is compatible with the sensor bandwidth (above 0.1Hz). The assembled cable, customizable in length according to the customer need, terminates with a breakout box, allowing fast connection to GeoSIG's recorders, as well as the *iSensor* module and quick pin-to-pin probing with oscilloscopes. The VE-53-DH comes equipped with a U-shaped wire for quick installation in the borehole and can be used to retrieve the sensor, when cement isn't used in the installation.

The VE-53-DH is available in 2 different variants:

- VE-53-SP-DH: Short Period version, 0.9 Hz (1.1 s) to 89 Hz Frequency Response
- VE-53-BB-DH: Broader Band version, 8.0 s (0.125 Hz) to 160 Hz Frequency Response

The VE-53-DH is the downhole version of the VE-53 surface sensors. The reason to use the downhole version in place of its surface counterpart is manifold:

- To minimize of the ambient noise, that mostly affect surface components on the seismograph.
- To guarantee a better coupling with the earth, by reducing influence of sediments or soft soil.
- To define the site condition to know the amplification factor. The velocity level at surface can be measured with a VE-53 and with downhole measurement where the amplification factor can be defined. This factor is highly dependent on local conditions and can vary to a great extent from one location to another.
- To reduce the maintenance costs involved in a vault site.

Figure 1: VE-53-DH downhole sensor

The VE53-DH is a precision measurement equipment and should be handled with care. Although the sensor is designed and manufactured to be robust to drop shocks, it is recommended to avoid to hit the sensor against hard surfaces.

Due to its long cylinder shape, when the sensor is placed on its base, there is a risk that it may fall. It is recommended that it is stored on its side, however care should be taken to prevent it in rolling and falling from the surface it is placed on.

1.1. VE-53-DH housing description

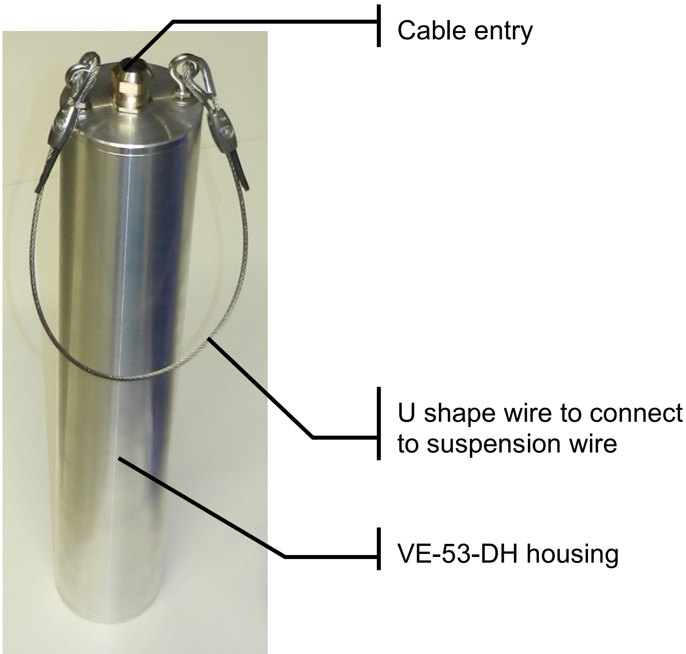


Figure 1.1: Housing description

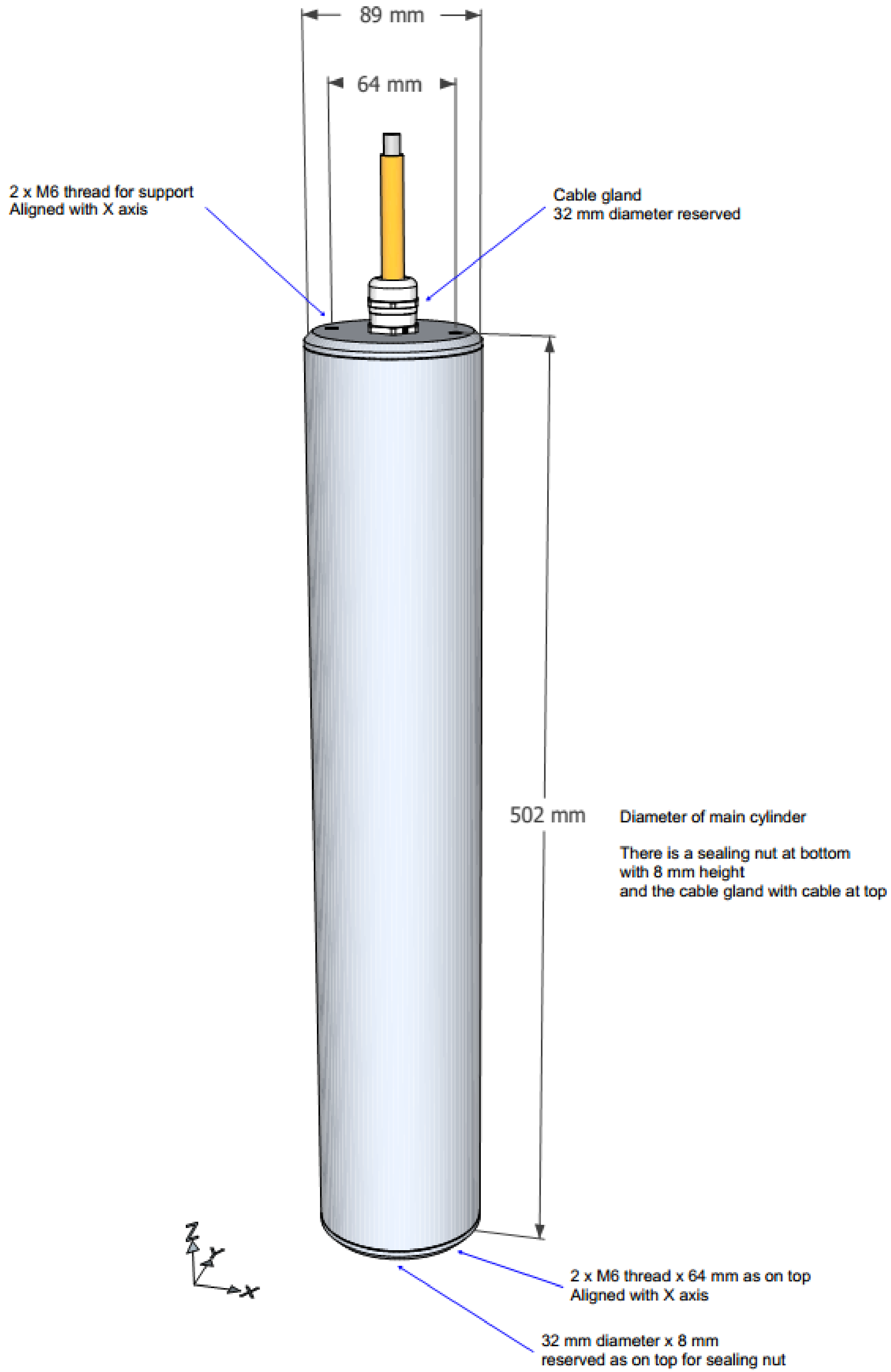
1.2. VE-53-DH specifications

Sensor Series	**VE-53-XX-DH**
Clipping level	20 mm/s
Full scale	10V differential output (+/-5V, single ended)
Sensitivity	1000 V/m/s differential (2 x 500 V/m/s, single ended)
Bandwidth	SP version: 0.9 Hz (1.1 sec) to 89 Hz, flat response BB version: 0.125 Hz (8 sec) to 160 Hz, flat response
Protections	All connector pins protected by TVS diodes for over-voltage and over-current
Digital interface*	*iSensor* module over RS-485 communication
Power supply	9.5 – 18 VDC
Current drain	Max 120mA @ 15 VDC, Typical 75 mA @ 15 VDC
Mechanical casing	Water immersion up to 10 bars (100m)

*if installed

Table 1.1: VE-53-DH specifications

1.3. Physical dimensions



2. Installation

The installation of a downhole sensor is a process that comprises of different steps: the preparation of an appropriate borehole on the designated test site, the proper laying of the sensor at the bottom of the borehole, the filling of the hole and the final connection. In this section, some guidelines and relevant information about the construction of a borehole and the installation of a VE-53-DH sensor are provided.

Section 2.1 provides a list of essential material to the construction of the site and installation of a VE-53-DH.

Section 2.2 highlights some useful considerations to take into account when using the VE-53-DH that may be used to properly design the construction of the borehole.

Finally, in Section 2.3 few examples of borehole constructions that are suitable for the deployment of the VE-53-DH are given.

2.1. Bill of Material

Before constructing the borehole, please make sure that cables length complies with the depth of the borehole and that the construction is well documented. Additionally, make sure that the essential material for the installation is available.

Here is an essential (not comprehensive) list of items needed to make the installation.

1) Items provided by GeoSIG:

- VE-53-DH sensor with: integral cable, suspension wire loop, junction box, if provided;
- Associated recorder for the sensor (e.g. GMS series or SMS recorder), if provided.

2) Tools required to communicate with the *iSensor* module (if installed):

- Laptop (Windows based) to run GeoSIG utility for *iSensor* module;
- A serial adapter for RS-485 like MOXA TCC-80I to interface the laptop serial port (or through a USB adapter) with the RS-485 interface of the sensor;
- Power supply (+/-15V, @200mA recommended) to power up the sensor during installation.

3) Items to be provided by the customer or subcontractor include:

- Depth probe with water level indicator to know the real depth of the hole;
- Steel wire for sensor suspension with the appropriate lock nut for the depth of the hole plus an additional length of at least 10 meters. Typically, stainless steel wire 3 mm diameter with a capacity of up to 100 kg;
- Grout injection tube and pump;
- A fixation tripod or tower and a pulley (preferable electric hoist) at the surface close to the borehole to hand over the steel wire;

2.2. Design notes

To guarantee the success of a VE-53-DH installation, the following considerations have to be taken into account, while designing the borehole installation.

- **Borehole diameter**: the VE-53-DH has shape of a cylinder of 89mm diameter. The borehole internal diameter has to be 100 mm as a minimum. Bigger diameters have to be considered as function of the borehole depth. It is recommended a diameter of 150mm or higher for downhole installations. See Section 2.3.3 for more details. A casing may be installed in the borehole. The decision depends mainly on the kind of rock to be bored. The point of the casing is only to provide integrity to the borehole during installation, which typically lasts several weeks. The casing has no effect on the sensor or signal during operation.

- **Borehole depth:** the VE-53-DH has watertight level guaranteed up to 10bar of pressure. Therefore, the level of water above the sensor in the borehole should never be more than 100 meters. While installed, the water level should be less than 50m to allow for rising water level during rain. In cases where there is water in the hole, combination of the chemical compositions and temperature should be evaluated for compatibility with the sensor housing material. This usually concerns installations located in areas with hot springs or near volcanoes.

- **Borehole levelling:** the installation method of the VE-53-DH doesn't requires the sensor to have any internal self-levelling or centring mechanism. Therefore, the tilt deviation of the borehole has to be guarantee to remain within the following specifications to ensure the sensor being well levelled at the sensor location in the borehole and preserve the alignment of signal axes:
    - The vertical angle of the borehole has to be $\boldsymbol{\alpha} < \mathbf{sin^{-1}}(\frac{\boldsymbol{d}}{\boldsymbol{2h}})$ where h = depth of installation and d = diameter of the hole. For example, a 150mm hole and 10m depth sensor must be drilled with an accuracy of 0.5°
    - The deviation at sensor location should be within ±2°, the absolute maximum deviation is ±5° from vertical.

  Alternatively, attention has to be put while the sensor is deployed in the borehole. And, in this last case, a bigger diameter of the borehole has to be considered. See Section 2.3 for more information.
- **Sensor orientation:** The depth of the borehole has an influence on how to perform the orientation of the sensor when it is placed into it. For shallow borehole (<3m) the north marking allows visual orientation to the earth magnetic North. For deeper installation, the sensor can come equipped with the *iSensor* module that includes a digital compass. Please note that its measurement will be only valid if no casing or if non-magnetic material (plastic, aluminium, fibre glass) is chosen for the casing. If a steel material is specified for the casing, the orientation of the sensor should be calculated using other techniques: for example, by referencing to some recorded earthquakes (or explosion data at a known azimuth) and the data recorded by a reference surface sensor at borehole top (see Section 2.3.3).

2.3. Example of installations

2.3.1. Example 1: Shallow bedrock installation

If bedrock can be easily reached, an excellent site for a downhole installation consists on bedrock covered by a few feet of soil. In this case, the borehole installation consists of digging a hole to bedrock, preparing the bottom, installing the seismometer and backfilling the hole.

The borehole can be with or without casing, depending on the soil material. Generally, a (steel or PVC) case makes sure that the integrity of the borehole walls is preserved and avoids ground material to fall in the hole before the sensor is installed and grouted. The case is fixed to the hole by means of cement that is injected in the annular region between the casing and borehole wall, generally over the full height of the casing. As a minimum, one week time should be allowed for curing of the cement.

Once the borehole is defined, the bottom of it has to be prepared before receiving the sensor. Different techniques and materials have been used for this scope. Two examples of shallow bedrock installations used at the Albuquerque Seismological Laboratory (ASL) are here reported:

- In a 1.2m downhole, the bottom of the borehole is covered in a 4cm layer of fine crushed glass,
- In a 5.5m cased borehole, 40 cm layer of fine sand fills up the bottom of the hole and a 15cm layer of crushed glass silica is added on top of the sand to form the base for the seismometer.

Alternatively, a solid base can be installed at the bottom of the borehole, provided that it can be levelled within the VE-53-DH tilt range (+/-2°).

Once the bottom is prepared, the sensor can be lowered in the borehole. The orientation to the North can be guaranteed by making use of the North mark of the sensor on top of its case. The usage of the optional *iSensor* module can be used to verify the levelling and the orientation of the sensor respectively to the magnetic North. See Section 4.3 for more information.

Different backfill materials can be used to bury the downhole sensor, like sand (to allow sensor being retrieved later) or cement (for permanent installation). In the latter case, it is not recommended to install the spare sensor in the same borehole, on top of the other sensor, but it is suggested to install and cap 1 or 2 additional boreholes, such that a spare sensor can be quickly installed, if required.

Once the sensor is deployed and the borehole fulfilled, the top end can be insulated and sealed with mortar and/or covered with an aluminium cap.

2.3.2. Example 2: Direct burial installation

In case the bedrock isn't easy or affordable to reach, the VE-53-DH can be also installed by direct burial in shallow hole (1.5m deep) with a pipe fitted into the hole to prevent the walls from collapsing. After sensor proper placement, the sand can be poured around the seismometer to approximately half its height. Vermiculite fills can be added on top. This installation was successful implemented at the PASSCAL Instrument Installation Center at Rio Grande Flood Plain, Sorocco, (New Mexico, USA) and it has shown good improvements from the vault site in the horizontal components of the seismic signal in the short-period bandwidth.

2.3.3. Example 3: Downhole installation

Downhole installations are generally suggested in presence of thick sediment environments. In that case, surface waves and resonances within sediment layer can affect the seismograph of the sensor. Drilling deeper in the ground, away from the surface and closer to the bedrock, mitigates the problem.

In a downhole installation, it is highly recommended to equip the VE-53-DH with the *iSensor* module to retrieve the sensor tilt and the alignment to the earth magnetic North.

Without the *iSensor* module: 1) to achieve levelling, a flat surface can be prepared at the bottom of the hole with self-leveling concrete, or a pre-levelled metal cap on which the sensor can sit on to; 2) to achieve orientation to north: a referencing earthquake (or explosion data at a known azimuth) is read by the deploying downhole sensor and by an additional reference surface sensor at borehole top and the downhole sensor is rotated along its vertical axis until the two seismographs are on good agreement.

The seismometer should not touch the side of the borehole, that has to be chosen carefully. To guarantee correct placement, the borehole diameter depends on the borehole depth and on the precision of tilt levelling it is achieved while drilling. Assuming that a levelling precision of +/-1° is guaranteed at the bottom of the borehole, the drill diameter has to be greater than 200mm. For higher tilt tolerance, a larger diameter borehole has to be considered.

Once the sensor is placed, it can be covered with backfill material (sand or cement or both). The required volume for the backfill to be used depends on the diameter of the borehole. Given the volume of the sensor (Vs = 3.12 dm^3), some examples of volume required are provided in Table 2.1.

borehole diameter [cm]	Height of backfill [m]	Backfill volume [dm^3]
10	0.502	0.9
10	1	4.8
150	0.502	5.8
150	1	14.6

Table 2.1: Example of volume for sensor backfilling

Generally, the following formula can be used to determine the volume required for the backfilling:

$$V = 0.1 * \pi r^2 h - Vs$$

With: V = Volume [dm3], r = radius of borehole (diameter/2) [cm], h = height of the cementation [meters]

If the installation does not utilize a casing, there must be an extra reserve for cementation of the sensor inside the borehole as there could be cavities in the earth that requires additional volume of cement.

A cap/box to avoid water ingress closes up the installation.

In *Figure 2.1* an example of downhole installation is given.

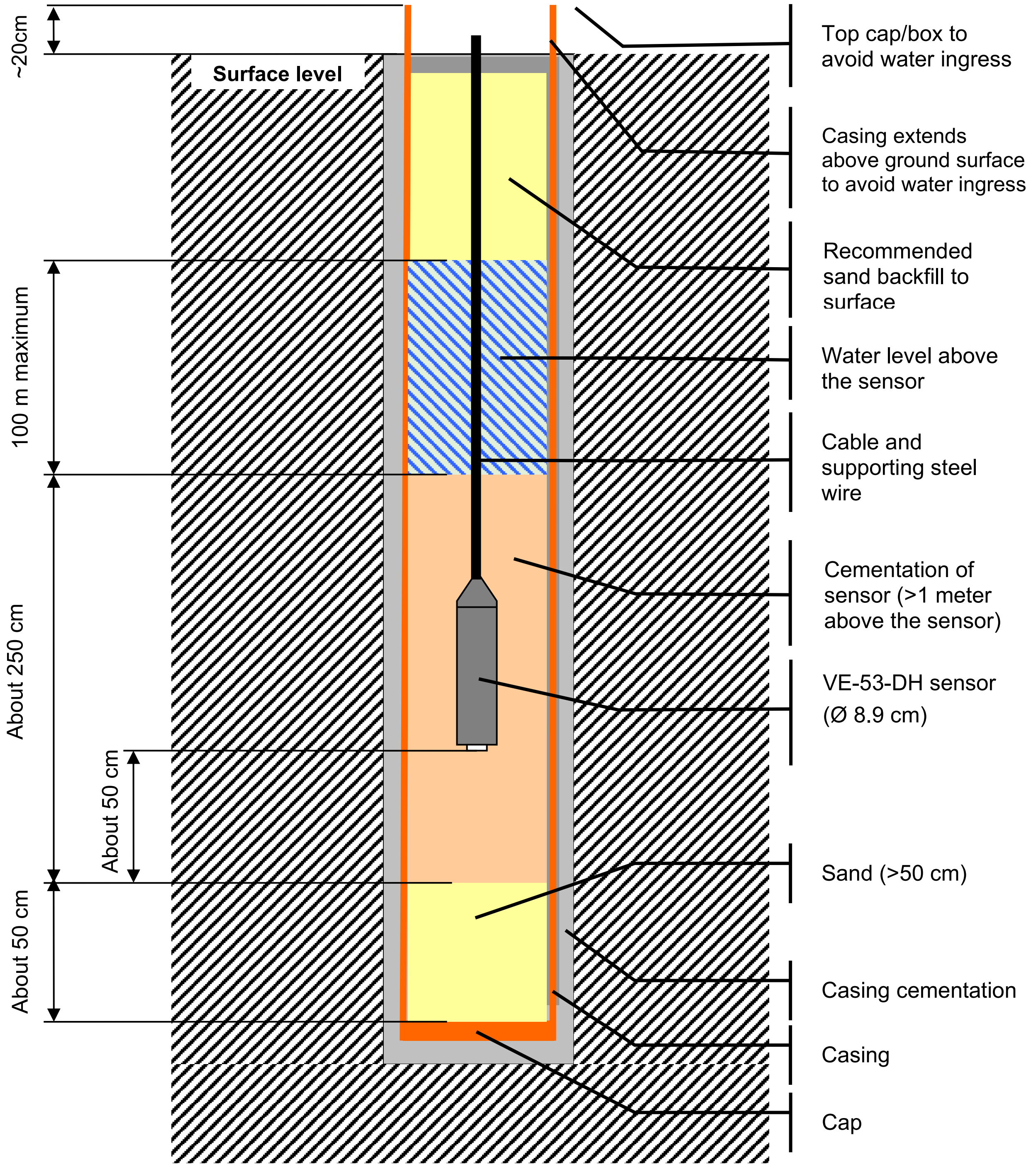


Figure 2.1: Example of downhole installation

3. Pinout and connectivity

All VE-53-DH velocity sensors are supplied with a preassembled cable, the length of which is specified by the customer at the time of the order. Based on the intended use, the sensor will be supplied in one of the following options:

- Open ended sensor cable (no junction box)
- With Binder connector 623 or 423 series (with junction box)

The Binder connectors allows the sensor to be connected to any GeoSIG's GMS recorders.

3.1. Open-end sensor

The standard connector pin assignment and cable colour code can be observed in Table 3.1:

Pin No.	Signal	Description	12 Lead Cable Colour	
1	OUTPUT X (+)	X-Signal high	**white**	
2	OUTPUT X (-)	X-Signal low	**brown**	
3	OUTPUT Y (+)	Y-Signal high	**green**	
4	OUTPUT Y (-)	Y-Signal high	**yellow**	
5	OUTPUT Z (+)	Z-Signal high	**grey**	
6	OUTPUT Z (-)	Z-Signal low	**pink**	
7	TEST INPUT	Sensor Test Signal	**blue**	
8	AGND	Analog Ground, isolated from Pin No.10	**red**	
9	+15 VDC	Power supply positive	**black**	
10	GROUND	Power return	**violet**	
11	RS-485 D-	RS-485 D- *iSensor* interface, RS-485, "DATA-"	**grey-pink**	
12	RS-485 D+	RS-485 D+ *iSensor* interface, RS-485, "DATA+"	**red-blue**	
shield	housing	Metal housing of the sensor	**braid**	

Table 3.1. VE-53-DH Internal PCB Pin Assignment

In case the user connects the sensor to a not GeoSIG recorder, we recommend a differential inputs recorder to read the seismic signal from the sensor, as shown in Figure 3.1.

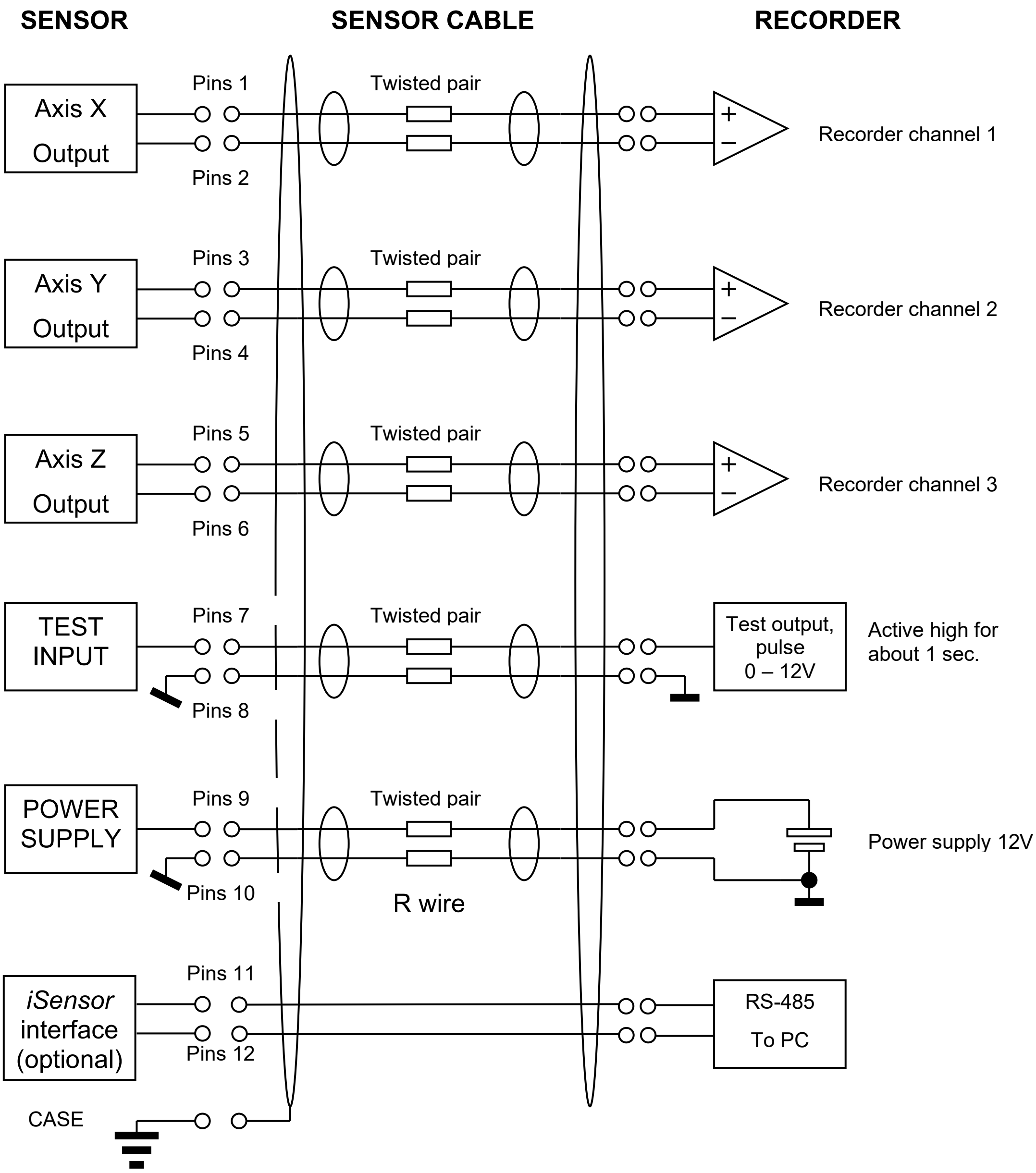
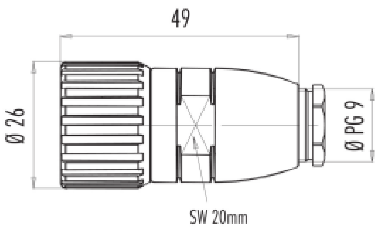


Figure 3.1: Open-ended connectivity to VE-53-DH sensor

Single ended connection can be used only for sensor testing. The *iSensor* module (if available) requires a RS-485 half duplex connection. Please refer to Section 4.3 for the intended connection to a PC.

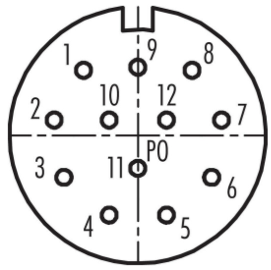
3.2. Sensor with Junction-Box and connectors

When the sensor is supplied with the connection junction-box, one of the following connector is installed.



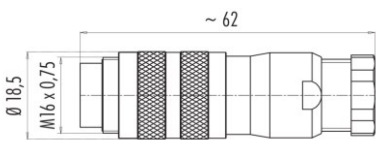
(a) Connection dimension

(b) Connector shape



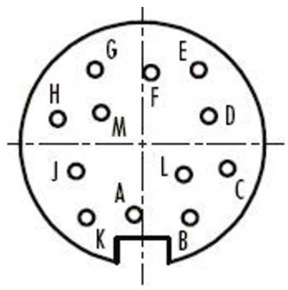
(c) Receptacle male connector

Table 3.2: Binder connector 623 Series



(a) Connection dimension

(b) Connector shape



(c) Receptacle female connector

Table 3.3: Binder connector 423 Series

Table 3.4 gives the PN of the standard Bider connectors used for the VE-53-DH sensor.

Binder Connector	Manufacturer PN	GeoSIG internal reference
623 series	99-4606-00-12	#J_CIR.012.008.F
423 series	99-5629-00-12	#J_CIR.012.010.M

Table 3.4: standard Binder connector PN

The above PN can differ in case the customer needs different cable between the junction box and the recorder. This can be the case if the voltage drop on the power supply line is a concern (see Section 3.3 for more information). The cable gland of the Binder connector is determined according to the cable's external diameter and must be ordered separately.

The standard connector pin assignment and cable colour code can be observed in the table below:

Binder Connector		SIGNAL	Comment	Colour	
Serie 623	Serie 423				
Pinout	Pinout				
1	A	OUTPUT X (+)	0 V ± 5 V voltage output, 50 Ω output impedance	White	
2	B	OUTPUT X (-)	0 V ± 5 V voltage output inverted, 50 Ω output impedance	Brown	
3	C	OUTPUT Y (+)	0 V ± 5 V voltage output, 50 Ω output impedance	Green	
4	D	OUTPUT Y (-)	0 V ± 5 V voltage output inverted, 50 Ω output impedance	Yellow	
5	E	OUTPUT Z (+)	0 V ± 5 V voltage output, 50 Ω output impedance	Grey	
6	F	OUTPUT Z (-)	0 V ± 5 V voltage output inverted, 50 Ω output impedance	Pink	
7	G	TEST INPUT	Test input, output will result in a sensor step response	Blue	
8	H	GND	Connected to Recorder's GND	Red	
9	J	+15V DC	Power input, +9.5 to +18 VDC range, 75 mA @ +15 VDC	Black	
10	K	GND	Connected to Recorder's GND	Violet	
11	L	RS-485 D-	RS-485 D- *iSensor* interface, RS-485, "DATA-" wire	Grey/Pink	
12	M	RS-485 D+	RS-485 D+ *iSensor* interface, RS-485, "DATA+" wire	Red/Blue	
housing	housing	shield	Sensor metal housing, connected to junction box housing	Braid	

Table 3.5: VE-53-DH Connector Pin Assignment and Cable Colour Code

3.3. Cable length

One of the most limiting parameters of the cable length is the voltage drop on the power supply lines. In typical installation scenario, the junction box is close to the recorder and the voltage drop over that cable is negligible.

On the other hand, the sensor cable can be rather long.

In Table 3.6, a lookup table comes helpful to define the possible sensor cable length in combination with power wire size and voltage supplies available.

Wire size (mm^2)	Junction-Box Type	Comment	Max cable length (m)
0.75	SEN-JB-GMS-3W		175
	SEN-JB-GMS-6W	(GeoSIG standard)	300
	Without JB, and 18V power supply		350

Table 3.6: max cable length

Other configuration can be evaluated with GeoSIG technical document.

4. Operating with the VE-53-DH

4.1. Sensor output voltage

The output signals of the VE-53-DH sensor are differential. This means that for each pair of signals, the negative Pin(-) provides same voltage in absolute value but negative in sign than the related positive Pin(+), while referencing to the analogue ground potential. Therefore, the difference between Pin(+) and Pin(-) results in double the voltage output.

The VE-53-DH has sensitivity of 1000V/m/s differential (500 V/m/s for each signal in the pair). Table 4.1 helps to convert from Volt to the velocity scale (mm/s).

Velocity [mm/s]	**Pin(+) voltage (*) [V]**	**Pin(-) voltage (*) [V]**	**Differential signal Pin(+) – Pin(-) [V]**
0	0	0	0
+1	+0.5	-0.5	+1.0
-1	-0.5	+0.5	-1.0
+10	+5.0	-5.0	+10.0
-10	-5.0	+5.0	-10.0

(*) Pin (+) apply to pins 1, 3 and 5, pin (-) apply to pins 2, 4 and 6.

Table 4.1: Sensor input versus output

4.2. Sensor testing

When the VE-53-DH sensor is powered, one way to test the sensor is to inject a mechanical pulse in constant velocity for a time duration of more than 5 seconds, and measure the output of the sensor. The relation between the mechanical input and the sensor voltage output is given by Table 4.1.

For example, moving the sensor at constant velocity of 1mm/s for 5-10secs in the direction of the target axis would result to read at the output of the sensor a voltage of 1V differential or +/-0.5V single ended at the corresponding axis. Meantime the other output pairs should remain close to zero.

Another way to test the sensor, is to apply an electrical pulse into the TEST INPUT pin and read the response of the sensor. The test input voltage simulates a mechanical pulse into the cell. The test pulse must be a 0V to 12V pulse signal. An internal circuit scales the generated pulse to a constant value and delivers it to the sensor cells. The following output voltage (single ended) is expected to be seen at the output of the sensor on each channel.

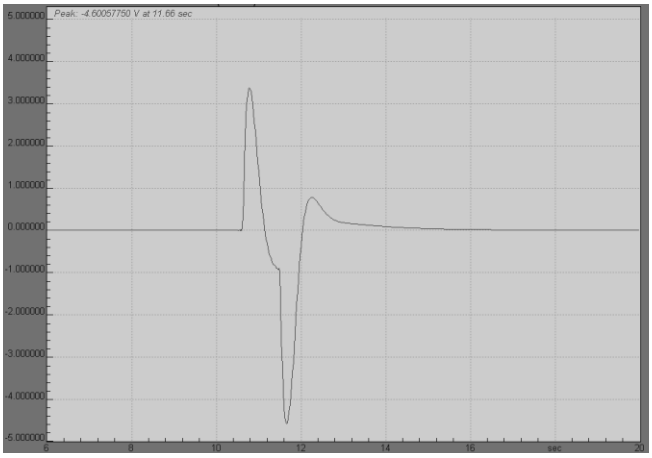


Figure 4.1: sensor test pulse

The TEST INPUT signal allows the user to quickly monitor the state-of-health of the sensor during its normal operation.

4.3. *iSensor* interface

The VE-53-DH sensor can be equipped with the *iSensor* module that contains:

- Humidity and Temperature sensor
- Tilt sensor
- Magnetic compass

The humidity and temperature sensor can be used for verification of the water tightness of the sensor after its installation and the temperature stability and average.

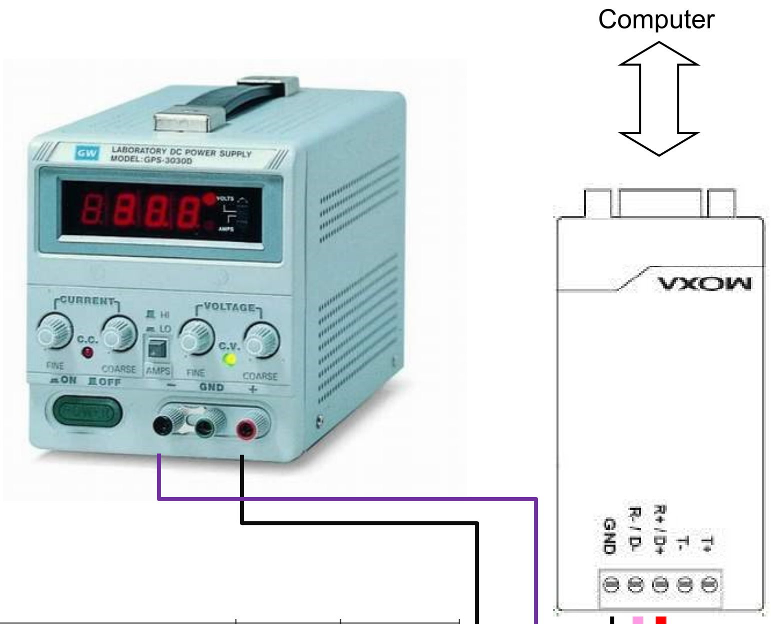
The tilt sensors give feedback if the sensor is aligned vertically in the down-hole.

The magnetic compass helps to align the sensor axes to the earth's magnetic North.

4.3.1. Preparation

To enable the communication with the *iSensor* module, the following equipment is needed:

- VE-53-DH sensor equipped with the iSensor module
- Laptop with serial port and iSensorUI software installed
- RS-485 to RS-232 converter (like MOXA TCC-80I)
- 15 VDC power supply, 200mA minimum current capability



9	+15 VDC	Power supply	**black**	
10	GROUND	Power Return	**violet**	
11	RS-485 D-	RS-485 D- iSensor interface, RS-485, "DATA-"	**grey-pink**	
12	RS-485 D+	RS-485 D+ iSensor interface, RS-485, "DATA+"	**red-blue**	

Figure 4.2: Connection to the *iSensor* module

4.3.2. Simple User Interface

Make sure that the sensor is powered and the setup is wired according to *Figure 4.2*. Then double-click on ***iSensor_Start.bat***.

The following command prompt appears

```
Enter COM Port Number:
```

Enter the number of the serial port that the sensor is connected to. In case of COM1, just type '1', in case of COM2, type '2', etc... If you are unsure about the serial port, please check in Windows under Start → Control Panel → System → Device Manager.

Only serial port numbers COM1 to COM9 are supported.

The following screen should appear, plotting the readings from the internal sensors every second.

```
Enter COM Port Number: 1
Time              T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 18:23:33   26.5     38.4    0.5          -0.5        203.0
2013/11/07 18:23:34   26.5     38.4    0.5          -0.5        203.0
2013/11/07 18:23:35   26.5     38.4    0.5          -0.5        202.4
2013/11/07 18:23:36   26.5     38.4    0.5          -0.5        203.0
2013/11/07 18:23:37   26.5     38.4    0.5          -0.5        203.2
2013/11/07 18:23:38   26.5     38.4    0.5          -0.5        203.5
2013/11/07 18:23:39   26.5     38.4    0.5          -1.0        202.9
2013/11/07 18:23:41   26.5     38.4    0.5          -1.0        202.8
2013/11/07 18:23:42   26.5     38.4    0.5          -1.0        202.5
2013/11/07 18:23:43   26.5     38.4    0.5          -1.0        202.9
```

Figure 4.3: iSensor console output

Time:	Time of the reading
T:	Temperature inside the VE-53-DH down-hole sensor in °C
RH:	Relative humidity inside the VE-53-DH down-hole sensor in %
TiltX:	Tilt of the VE-53-DH sensor tube in direction of the X axis in °
TiltX:	Tilt of the VE-53-DH sensor tube in direction of the Y axis in °
MH:	Magnetic heading of the Y axis. When the MH is showing 0°, then the Y-axis points to the direction north. In case of 90°, the Y-axis points east, 180° for south and 270° for west.

At the same time, the values are logged into the file ***iSensor_Output_YYYYMMDD_HHMMSS.csv***, whereas

YYYYMMDD_ HHMMSS stands for the year (YYYY), month (MM), day (DD), hour (HH), minute (MM) and second (SS) when the measurement has started. For example the file name could be: ***iSensor_Output_20131107_182333.csv***

The program measurement can be stopped by closing the command prompt window or pressing ***<CTR> + 'C'***.

The CSV file can be opened by any text editor or the Microsoft Excel for further analysis.

	A	B	C	D	E	F	G
1	Time	T(C deg)	RH(%)	TiltX(deg)	TiltY(deg)	MH(deg)	
2	07.11.2013 18:23	26.5	38.4	0.5	-0.5	203	
3	07.11.2013 18:23	26.5	38.4	0.5	-0.5	203	
4	07.11.2013 18:23	26.5	38.4	0.5	-0.5	202.4	
5	07.11.2013 18:23	26.5	38.4	0.5	-0.5	203	
6	07.11.2013 18:23	26.5	38.4	0.5	-0.5	203.2	
7	07.11.2013 18:23	26.5	38.4	0.5	-0.5	203.5	
8	07.11.2013 18:23	26.5	38.4	0.5	-1	202.9	
9	07.11.2013 18:23	26.5	38.4	0.5	-1	202.8	
10	07.11.2013 18:23	26.5	38.4	0.5	-1	202.5	
11	07.11.2013 18:23	26.5	38.4	0.5	-1	202.9	
12							
13							

Figure 4.4: CSV file opened in Microsoft Excel

4.3.3. Compass Calibration

Compass is factory calibrated. However, it is recommended to repeat the calibration before the installation of the VE-53-DH sensor is started.

Make sure that the sensor is powered and the setup is wired according to Figure 4.2.

Then double-click on ***iSensor_Compass_Calibration.bat***.

The following command prompt appears:

```
Enter COM Port Number:
```

Enter the number of the serial port to which the sensor is connected. In case of COM1, just type '1', in case of COM2, type '2', etc... If you are unsure about the serial port, please check in Windows under Start → Control Panel → System → Device Manager.

Only serial port numbers COM1 to COM9 are supported.

Then follow the instructions on the screen. After the calibration is finished, the correction factors are stored into the *iSensor* module.

4.3.4. Expert Mode

A double-click on ***iSensor_Expert.bat*** starts the expert mode of the iSensorUI software. The help content will be shown immediately.

The iSensorUI software can be started with several parameters.

```
isensorui -parameter value
```

Parameter	Value	Description
-h	-	Shows the help text
-a	show-sensors	Shows the measurements of the *iSensor* module
	Show-fw-ver	Shows the firmware version of the *iSensorUI*
	calibrate-compass	Starts the calibration of the compass
-p	COM1, COM2, COM3, ...	Serial port for the communication with the sensor
-b	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	Baud rate of the serial port (default is 9600)
-s	1, 2, 3, ...	Slave address of the *iSensor* module (default is 1)
-t	1 ... 3600	Delay in secs between the measurements (default is 1)
-l	1, 2, 3, ...	Limit the read values by the specified value. Program stops when the specified measurements have been done
-o	filename.csv	Print the sensor values to the selected CSV file
-V	**-**	Show the version of the software

Table 4.2: *iSensor* interface, command syntax

4.3.5. Example 1

The sensor is connected to **COM1** and ***iSensor* values shall be plotted**.

```
isensorui -p COM1 -a show-sensors
```

Then the sensor sends the measurements as shown below to the screen.

```
Time                T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:39:35  26.5    38.1    0.5         -0.5        203.0
2013/11/07 16:39:36  26.5    38.1    0.5         -1.0        203.0
2013/11/07 16:39:37  26.5    38.1    0.5         -1.0        202.4
2013/11/07 16:39:38  26.5    38.1    0.5         -1.0        203.0
2013/11/07 16:39:39  26.5    38.1    0.5         -1.0        203.2
```

4.3.6. Example 2

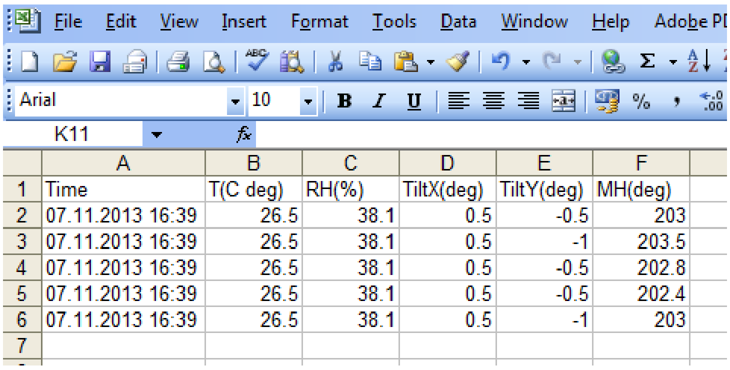
The sensor is connected to **COM4** and ***iSensor* values shall be plotted and saved to the file *installation.csv* every 5 seconds**.

```
isensorui -p COM4 -a show-sensors -o installation.csv -t 5
```

Then the sensor sends the measurements as shown below to the screen.

```
Time                T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:39:35  26.5    38.1    0.5         -0.5        203.0
2013/11/07 16:39:40  26.5    38.1    0.5         -1.0        203.5
2013/11/07 16:39:45  26.5    38.1    0.5         -0.5        202.8
2013/11/07 16:39:50  26.5    38.1    0.5         -0.5        202.4
2013/11/07 16:39:55  26.5    38.1    0.5         -1.0        203.0
```

Additionally, the data are stored in the CSV file *installation.csv*



	A	B	C	D	E	F
1	Time	T(C deg)	RH(%)	TiltX(deg)	TiltY(deg)	MH(deg)
2	07.11.2013 16:39	26.5	38.1	0.5	-0.5	203
3	07.11.2013 16:39	26.5	38.1	0.5	-1	203.5
4	07.11.2013 16:39	26.5	38.1	0.5	-0.5	202.8
5	07.11.2013 16:39	26.5	38.1	0.5	-0.5	202.4
6	07.11.2013 16:39	26.5	38.1	0.5	-1	203
7						

4.3.7. Example 3

The sensor is connected to **COM2** and only **3 measurements** with **an interval of 20 seconds** **shall be read out from the *iSensor***.

```
isensorui -p COM2 -a show-sensors -l 3 -t 20
```

The reading stops after 3 measurements.

```
Time                T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:40:00   26.5     38.1    0.5         -0.5        203.0
2013/11/07 16:40:20   26.5     38.1    0.5         -0.5        202.4
2013/11/07 16:40:40   26.5     38.1    0.5         -0.5        202.8
```

5. Appendix

5.1. VE-53 (VE-53-DH), principle of operation

The VE-53 (VE-53-DH) is a short-period seismometer. Its working principle is based on a geophone mass-spring system with electronic correction. This type of sensor gives a very good stability in temperature and aging because of the very simple principle. It uses a damped mass spring oscillator called "Geophone" to convert seismic movement into electrical value proportional to the velocity. In a graphic with constant acceleration, the geophone response will present a maximum at the frequency called "Natural Frequency" which is the resonant frequency of the mass-spring oscillator. The VE-53 (VE-53-DH) uses Geophones with natural frequency of 4.5Hz. Above and below this point, the response will decay with one pole slope (±20 dB / decade).

The principle of implementation is given in Figure 5.2 and is hereafter explained.

The geophone is connected in a resistor bridge, driven by the low noise feedback amplifier, which applies the amplified bridge differential signal as an opposite polarity current. The bridge is zero balanced during the manufacturing process.

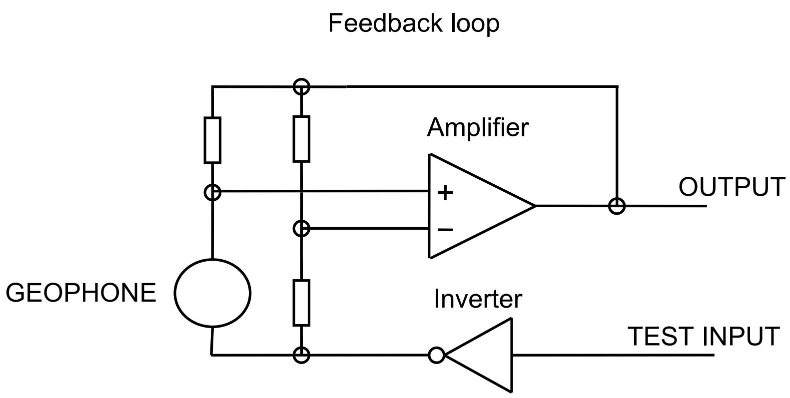
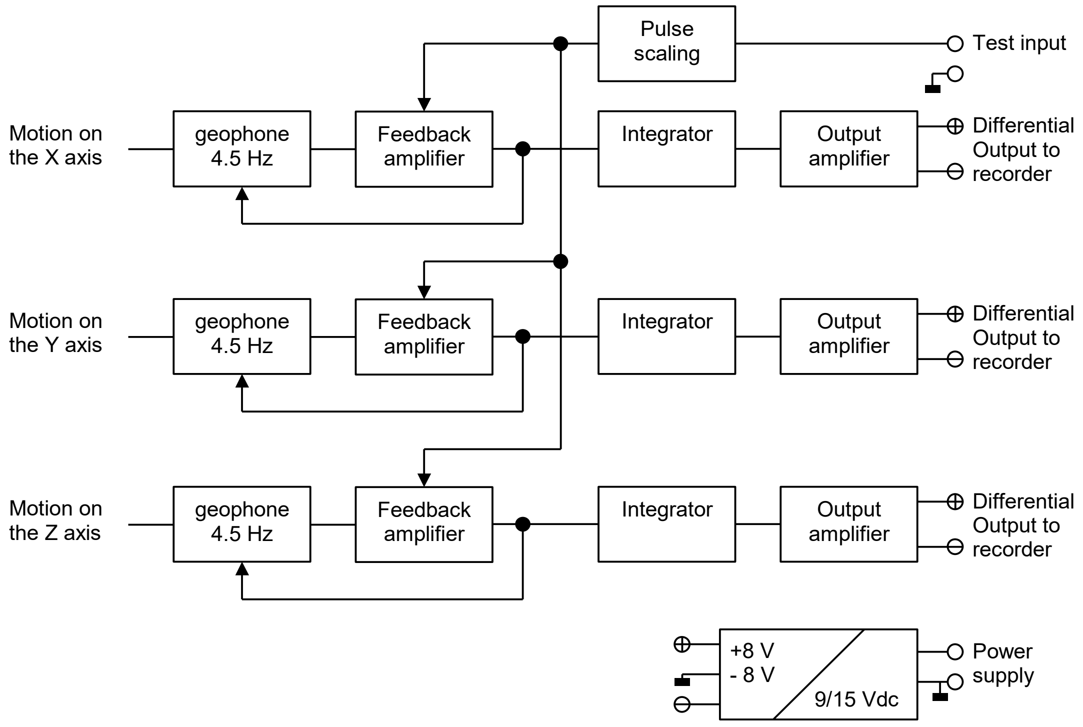


Figure 5.1: Geophone electronics and TEST INPUT configuration

The feedback amplifier will over-damp the geophone by applying a voltage with opposite polarity over the geophone and the output response will be flat and proportional to the acceleration in this frequency band.

Cascaded to the output stage, an integrator is implemented to convert the acceleration signal into a velocity signal, that is then converted to differential mode by the output buffer.

Finally, the TEST INPUT signal shifts the voltage at one side of the bridge, which produces a current flow in the geophone. This current flowing in the Geophone will move the seismic mass, emulating a mechanical input to the cell. The movement of the mass generates a voltage across the Geophone, which is detected by the differential amplifier and induces an output signal.



Note : all inputs, outputs & power supply entry are surge protected.

Figure 5.2: VE-53-DH Sensor block diagram